Before the
FEDERAL COMMUNICATIONS COMMISSION
Washington, D.C. 20554

In the Matter of	)	
	)	
	)	
Amendment of Part 15 of the Commission's Rules Regarding Spread Spectrum Devices	)	ET Docket No. 99-231
	)	
	)	

Comments of Nokia Inc.

Nokia Inc. ("Nokia"), pursuant to Section 1.415 of the Rules of the Federal Communications Commission ("Commission"),[1] respectfully submits these Comments in response to the *Notice of Proposed Rule Making* in the above-captioned proceeding.[2]

I. Introduction and Overview

Nokia is the world's leading supplier of mobile telephones and is a global leader in the manufacture of telecommunications infrastructure including mobile, fixed, and Internet Protocol networks. Nokia maintains manufacturing facilities in 10 countries and has more than 51,000 employees in over 45 countries around the world, including over 6,000 employees in the United States. Nokia is paving the way to the mobile information society with its innovative products and solutions.

As a strategic region for developing new services and products, the U.S. is of vital importance to Nokia's various businesses. Included in Nokia's product portfolio are

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[1] 47 C.F.R. § 1.417.

[2] ET Docket No. 99-231, *Notice of Proposed Rule Making* (FCC 99-149, rel. June 24, 1999), ("*Notice*").

devices operating under Part 15 of the Commission's rules for providing low power wireless communications in the 2.400 – 2.4835 GHz Industry, Science and Medicine ("ISM") band. Nokia has invested a great deal of resources developing equipment for this band and is continuing to develop new and innovative applications for this unlicensed band. Consequently, Nokia has a direct and important interest in the proposals made by the Commission in the *Notice*.

II. Discussion

In the NPRM, the Commission proposes to amend its rules to permit frequency hopping systems to use wider bandwidths than is currently allowed under the Commission's Rules, as suggested by the Home RF Working Group ("HRFWG"), a coalition which purports to represent over fifty wireless radio companies.[3] In particular, the Commission stated that it:

> Recognize[d] that spectrum occupancy of frequency hopping systems in the 2.4 GHz band will increase as a result of the proposed changes. The existing rules require a minimum of 75 hopping channels each with a bandwidth of no more than 1 MHz. Given the 83.5 MHz of spectrum available in the 2.4 GHz band, no frequency is used more than once in the hop sequence. However, if the channel bandwidth is increased to 3 MHz or 5 MHz, overlapping channels will be needed to accommodate 75 hops. Accordingly, the average time of occupancy on any one frequency will increase. However, it appears that the proposed reduction in output power and time of occupancy would offset any potential increase in interference. Further, we observe that manufacturers of direct sequence systems that are concerned about interference can improve the robustness of their systems by increasing processing gain.[4]

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3 *Notice* ¶ 8.
4 *Id.* ¶ 9.

In response to the Commission's proposal, Nokia conducted analysis and simulation related to the demodulation of 1 MHz frequency hopped radios using frequency shift keying (FSK) modulation. FSK is used in IEEE802.11, Bluetooth and HomeRF radio systems due to the existence of low cost reception techniques. One attribute of systems using FSK is that the noise at the input to the receiver is amplified during demodulation at a rate that is proportional to the square of the frequency difference between the noise and the carrier. This relationship can be found for example in Proakis and Salehi.[5] The impact of this noise enhancement relationship is that collisions between frequency hopped systems with a frequency offset will be more detrimental than collisions that occur on the same frequency.

To limit the impact of interference in FSK frequency hopped radios, a band pass filter is used when the radio signal is downconverted to baseband where a typical IEEE802.11 system has an effective radio bandwidth of 3 MHz. Thus, within the 3 MHz bandwidth, the model used in Nokia's analysis is as described above where the interference is amplified using a square law. The next step in the analysis technique was to examine the probability of error for a system that is comprised of only 1 MHz hoppers with non-overlapping frequencies and the inclusion of 3 and 5 MHz hoppers with overlapping frequencies. These two analyses will offer a comparison of the error rate for frequency hopped radios under the current Part 15 rules and operation using wideband frequency hoppers under the proposed rule making.

5 Proakis, J.G. and M. Salehi, Communication Systems Engineering, Prentice Hall, Englewood Cliffs, NJ, p. 410.

The probability of a bit error is the metric chosen to assess the performance of the radio system because errors result in retransmissions, causing a decrease in the amount of information the radio system can deliver per unit time. To calculate the probability of error for the optimal 1 MHz noncoherent receiver, Nokia calculated the probability that a collision occurs between systems with only 1 MHz non-overlapping frequency hoppers and with 3 and 5 MHz overlapping frequency hoppers and determined the bit error rate should a collision occur. The results are shown in Table 1 for a few key points. Note that the error rate under the current Part 15 rules is lower than that shown under the proposed rule making. The increase in probability of error on the 1 MHz frequency hopped system from wideband hoppers is due to the increased occurrence of collisions with a frequency offset between the desired signal under demodulation and the interfering signal. To further verify Nokia's conclusions, a simulation was performed using a phase locked loop receiver; which is a common technique for FSK demodulation. The results shown in Table 1 were duplicated, in that wideband frequency hoppers caused an increase in the probability of error. This increase in probability of error may reduce the effective throughput of an IEEE802.11 system by approximately 10 to 20 %, depending upon load, due to retransmissions.

Ratio of Desired Signal Power to Interfering Signal Power	1 MHz Interfering Signal	3 MHz Interfering Signal	5 MHz Interfering Signal
8 decibels	5×10^{-4}	1.5×10^{-3}	2×10^{-3}
10 decibels	7×10^{-5}	2×10^{-4}	2×10^{-4}

Table 1 Bit Error Rate Performance Assuming Part 15 1 MHz Hop Frequencies and with the Proposed Extension to 3 MHz and 5 MHz Hoppers

Another performance impact of overlapping frequencies is the difficulty in performing a clear channel assessment (CCA). The foundation of the IEEE802.11 system is a protocol called Carrier Sense Multiple Access with Collision Avoidance (CSMA-CA). The collision avoidance mechanism depends upon a terminal's ability to perform a CCA. With non-overlapping frequencies and 1 MHz hop frequencies, waveform detection techniques can be used to produce reliable estimates of when the channel is occupied. With overlapping frequencies and wideband frequency hoppers, CCA function can only be performed using energy detection. Thus, the effective throughput of the radio system will be further reduced from the figures quoted above.

III. Conclusion

For the forgoing reasons, Nokia urges the Commission to reject the proposed changes in the Part 15 rules governing frequency hopping systems in the 2.4 GHz band. As demonstrated herein, the proposed rule changes will have significant negative impacts on the installed base of radio systems currently operating under Part 15 rules.

Respectfully submitted,

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CERTIFICATE OF SERVICE

I, Claudia Cheek, hereby certify that on this 4th day of October, 1999, copies of the foregoing "Comments of Nokia Inc." in ET Docket No. 99-231, were served by first class U.S. mail to the following:

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